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MULTIWAVELENGTH OBSERVATIONS REVEALING THE OUTBURSTS OF THE TWO SOFT X-RAY TRANSIENTS XTE J1859+226 AND XTE J1118+480

S. Chaty[1], C.A. Haswell[1], R.I. Hynes[2], C.R. Shrader[3] and W. Cui[4]

Abstract

We report multiwavelength observations of the two soft X-ray transients (SXTs) XTE J1859+226 and XTE J1118+480, which we observed with *HST*, *RXTE* and UKIRT. The two sources exhibited very different behaviour. XTE J1859+226 showed a thermal-viscous disc instability outburst modified by irradiation. XTE J1118+480, which we also observed with *EUVE* since it is located at a very high galactic latitude and suffers from very low extinction, is much more unusual. It exhibits i) a low X-ray to optical flux ratio and ii) a strong non-thermal contribution throughout the spectrum, which is likely to be due to synchrotron emission. We concentrate here on their evolution in the course of their outbursts.

1 Introduction

SXTs, also called X-ray novae, are a class of low mass X-ray binaries (LMXBs), including GRO J1655–40 and GRO J0422+32. More than 70% of SXTs are thought to contain black holes (Charles, 1998). The compact object accretes matter through an accretion disc from a low-mass star via Roche lobe overflow. The history of these sources is characterized by long periods of quiescence, typically lasting decades, and punctuated by very dramatic outbursts, visible at every wavelength. These sources are usually discovered in X-rays or the optical, and often exhibit radio activity. Two such sources were discovered respectively in 1999 and 2000: XTE J1859+226 and XTE J1118+480. Thanks to our pre-approved override programs on *RXTE*, *HST* and UKIRT we could get early multiwavelength

[1] Department of Physics and Astronomy, The Open University, Milton Keynes, UK, s.chaty@open.ac.uk
[2] Department of Physics and Astronomy, University of Southampton, Southampton, UK
[3] Laboratory for High-Energy Astrophysics, NASA GSFC, Greenbelt, USA
[4] Department of Physics, Purdue University, West Lafayette, IN 47907, USA

observations of these systems, and follow their evolution from outburst towards quiescence.

2 XTE J1859+226

The first source, XTE J1859+226, was discovered by ASM/*RXTE* on 1999 October 9 at the galactic coordinates: $(l, b) = (54.05°, +8.61°)$ (Wood et al., 1999). This source exhibited a fast rise ($\sim$ 5 days) and exponential decay ($\sim$ 23 days) typical of SXTs. The optical counterpart reached 15th magnitude at its maximum (Garnavich et al., 1999) exhibiting a period of 9.15 +/- 0.05 hr (Garnavich & Quinn, 2000), later shown to be the orbital period by Filippenko & Chornock (2001), who also determined the mass function of this object: $f(M) = 7.4 \pm 1.1\ M_{\odot}$ (the highest known), implying the compact object is a black hole.

The early spectral energy distribution (SED) which we observed (see Fig. 1) is well fitted by a typical X-ray irradiated disc model ($T \propto R^{-3/7}$). The model used was actually generated to fit the SED of GRO J0422+32 in outburst, which has an orbital period of 5.1 hr, and then scaled to fit the new data with no other adjustment. If the disc were heated by viscous processes instead of irradiation we would expect intead to see $f_{\nu} \propto \nu^{1/3}$ (corresponding to $T \propto R^{-3/4}$). Gratifyingly, this is seen in our last visit where the SED is better fitted by a viscously heated accretion disc model with an edge temperature of $\sim$ 8000 K, suggesting evolution from an irradiation dominated to viscosity dominated regime.

3 XTE J1118+480

The second source, XTE J1118+480, was discovered by *RXTE* on 2000 March 29 (Remillard et al., 2000) as a weak, slowly rising source, the post-analysis revealing an outburst in January 2000, with a similar brightness. The optical counterpart is a 13th magnitude star, coincident with a 18.8 mag object in the DSS (Uemura et al., 2000). This system was characterized by a very low X-ray to optical flux ratio of 5 (Uemura et al., 2000); the typical value is 500 (see e.g. Tanaka & Shibazaki 1996). A weak photometric modulation of 4.1 hr (0.17082 d) period was rapidly discovered (Cook et al., 2000), which was associated with the orbital period, the shortest among the black hole candidates. Flickering with an amplitude of $\sim$ 0.4 mag, and also a quasi-periodic oscillation (QPO) at 10 s, was observed in the optical, in the UV (Haswell et al., 2000) and also in the X-rays with an evolving frequency (Wood et al., 2000). The large value of the mass function, $f(M) = 5.9 \pm 0.4\ M_{\odot}$, implies the compact object is a black hole (Wagner et al. 2000 and McClintock et al. 2001). The location of this object at a high galactic latitude $(l, b) = (157.62°, +62.32°)$ is very unusual, and there is a very low absorption along the line of sight of the source, with a column density estimated to $N_H \sim 1.0 - 1.6 \times 10^{20}$ cm^{-2} (see Hynes et al. 2000, Chaty et al. 2001, hereafter respectively H00 and C01).

Our unprecedented broadband coverage of the SED, shown in Fig. 2 (see also H00 and C01), suggests that the system was exhibiting a low-state mini-outburst, with the inner radius of the accretion disc at $\sim 200 - 300 R_s$ (R_s: Schwarzschild

radius). The SED shows a flat power-law spectrum from the radio to the NIR, from the NIR to the UV, and in X-rays, suggesting that there is another source of flux apart from thermal disc emission (see also Markoff et al. 2001). Furthermore, the SED did not evolve much during the 3 months of our coverage, a behaviour similar to that of jet sources such as GRS 1915+105 and GX 339-4 (Tanaka & Shibazaki, 1996). We detected flickering at NIR wavelengths, of bigger amplitude (~ 0.8 mag) than in the optical (~ 0.4 mag). All these facts, combined with the ~ 10 s QPO seen in the optical, UV and X-rays, suggest a strong **non-thermal (likely synchrotron) emission** present from the radio to the X-rays (C01).

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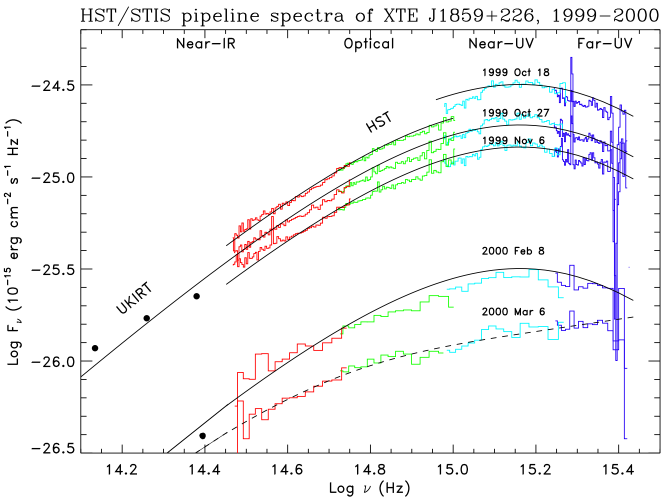

Figure 1 – From irradiated to viscously-heated: *an irradiated spectrum ($T \propto R^{-3/7}$) fits the SED during the outburst (top curves) while a viscously heated disc ($T \propto R^{-3/4}$) matches the bottom, near quiescent SED.*

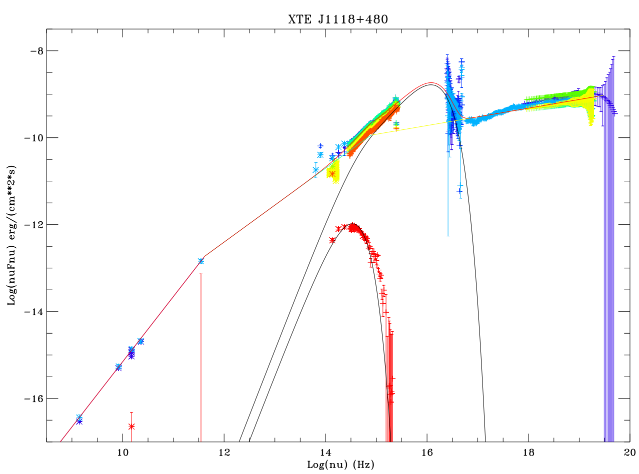

Figure 2 – Spectral Energy Distribution: *Shown here are all the observations of XTE J1118+480 in an interval of 3 months. The last HST and UKIRT observations of the source in near-quiescence are reported at the bottom of the Figure, fitted by a black body representing the companion star. The fluxes are corrected from interstellar absorption with $N_H = 1.0 \times 10^{20}$ cm^{-2}. The model fitting approximatively all the observations in a period of 3 months is the sum of: one steady-state disc model with an outer disc at 8000K and inner disc radius at $350 R_s$, 3 power laws of spectral indices respectively 0.5, -0.15 and -0.8 and the black-body representing the companion star (see also C01 and H00).*